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A Review of Traumatic Brain Injury Trauma Center Visits Meeting Physiologic Criteria from the American College of Surgeons Committee on Trauma/Centers for Disease Control and Prevention Field Triage Guidelines

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Abstract

Background—Traumatic brain injury (TBI) represents a serious subset of injuries among persons in the United States, and prehospital care of these injuries can mitigate both the morbidity and the mortality in patients who suffer from these injuries. Guidelines for triage of injured patients have been set forth by the American College of Surgeons Committee on Trauma (ACS-COT) in cooperation with the Centers for Disease Control and Prevention (CDC). These guidelines include physiologic criteria, such as the Glasgow Coma Scale (GCS) score, systolic blood pressure, and respiratory rate, which should be used in determining triage of an injured patient.

Objectives—This study examined the numbers of visits at level I and II trauma centers by patients with a diagnosed TBI to determine the prevalence of those meeting physiologic criteria from the ACS-COT/CDC guidelines and to determine the extent of mortality among this patient population.

Methods—The data for this study were taken from the 2007 National Trauma Data Bank (NTDB) National Sample Program (NSP). This data set is a nationally representative sample of visits to level I and II trauma centers across the United States and is funded by the American College of Surgeons. Estimates of demographic characteristics, physiologic measures, and death were made for this study population using both chi-square analyses and adjusted logistic regression modeling.

Results—The analyses demonstrated that although many people who sustain a TBI and were taken to a level I or II trauma center did not meet the physiologic criteria, those who did meet the physiologic criteria had significantly higher odds of death than those who did not meet the criteria.

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The findings of this study are those of the authors and do not necessarily represent those of the Centers for Disease Control and Prevention.

The authors report no conflict of interest.

After controlling for age, gender, race, Injury Severity Score (ISS), and length of stay in the hospital, persons who had a GCS score ≤13 were 17 times more likely to die than TBI patients who had a higher GCS score (odds ratio [OR] 17.4; 95% confidence interval [CI] 10.7–28.3). Other physiologic criteria also demonstrated significant odds of death.

Conclusions—These findings support the validity of the ACS-COT/CDC physiologic criteria in this population and stress the importance of prehospital triage of patients with TBI in the hopes of reducing both the morbidity and the mortality resulting from this injury.

Keywords

traumatic brain injury; trauma centers; triage; criteria

Introduction

In the United States, injury is the leading cause of death for persons aged 1–44 years.[1] Traumatic brain injury (TBI) represents a significant subset of serious injuries and is an important public health problem that affects approximately 1.7 million Americans every year.[2] Of all injury deaths in the United States, one in three cases is TBI-related, and an estimated 5.3 million Americans are living with a TBI-related disability.[1,3,4] In addition to the major morbidity and mortality caused by TBI, its economic burden is estimated to be in excess of $60 billion.[5,6]

Prehospital management of TBI patients and the implementation of field triage guidelines are complex yet key aspects of care that can significantly impact both the patient outcomes and the economic burden of TBI. Early identification of the signs and symptoms of TBI by emergency medical services (EMS) providers may allow for early intervention, which has a significant impact on the outcome of these patients.[7,8] Integral to the assessment and management of TBI patients is the triage process, which seeks to send trauma patients in a safe and timely manner to the most appropriate level of care in the defined trauma system as dictated by the American College of Surgeons Committee on Trauma (ACS-COT) and Centers for Disease Control and Prevention (CDC) Guidelines for Field Triage of Injured Patients, which have been in existence since their original form in 1986 and most recently revised in 2006.[9,10] Patients with TBI should be preferentially taken to a facility with capabilities for immediate head-injury diagnosis and intervention; in patients with severe TBI (Glasgow Coma Scale [GCS] score of 3–8), this is usually a high-level trauma center.[11]

In the 2006 revision, the ACS-COT/CDC field triage guidelines seek to determine the need for transport to a trauma center using physiologic, anatomic, mechanistic, and special consideration criteria, which are considered sequentially in that order. These recommendations seek to keep the undertriage rate below 5% while accepting a rate of overtriage between 25% and 50%.[10] More specifically, the physiologic (Step One) criteria are aimed at guiding EMS providers in promptly identifying critical trauma patients through assessment of vital signs as well as level of consciousness. These criteria include assessment of respiratory rate and systolic blood pressure (SBP) in addition to the GCS score, which has been shown to be a significant and reliable marker of TBI severity.[11] The accuracy of individual triage criteria has been extensively evaluated.[12–21] In particular, of the four categories of criteria, the physiologic criteria have been identified as having the highest yield for identifying trauma center patients.[12–19] Furthermore, some authors have proposed that the physiologic criteria alone (or in combination with anatomic criteria) may be sufficient to accurately predict need for a trauma center.[12–16]

Correct triage of a trauma patient to a trauma center has been shown to lead to a 25% decrease in mortality;[21,22] however, optimal treatment and triage of TBI patients represent an ongoing challenge as well as a key avenue of improvement. Although the Step One physiologic criteria have been evaluated in their reliability for trauma patients in general, no studies have examined these published criteria as they pertain specifically to TBI patients. In order to further address the challenges facing public health policies and prehospital guideline formation, the current investigation utilizes national data to evaluate TBI trauma center visits meeting the ACS-COT/CDC physiologic criteria and to subsequently assess mortality in this population.

Methods

The data for this study were taken from the 2007 National Trauma Data Bank (NTDB) National Sample Program (NSP).[23]

The NTDB-NSP is a subsample of the entire national trauma database that is managed by the American College of Surgeons and is intended to produce a data set from which national estimates can be made for visits to level I and II trauma centers in the United States. The sampling universe is created with the National Inventory of Hospital Trauma Centers. Only level I and II trauma centers are sampled from this sampling universe based on the probability of selection proportional to size (PPS) methodology and are stratified by U.S. Census Region, trauma center designation, and NTDB reporting status, which produces a complex design. Final weights are developed and applied to each visit collected from each trauma center and adjusted by the number of emergency department visits for each month of the collection year. These weights allow national estimates to be made. Further explanation of the sampling methodology can be found at http://www.facs.org/trauma/nsp/samplecreation.pdf.

In the 2007 NTDB-NSP data set, there were a total of 82 level I and II trauma centers from which data were collected. The unit for analyses in this data is the injury incident, which is weighted to represent all injury incidents presenting to level I and II trauma centers in the United States during the study period.

Our study population comprised injury incidents that included a diagnosis of TBI. Traumatic brain injury was identified using the *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM) codes collected from the trauma registry. The CDC definition of TBI was used and included the following codes: 800.0–801.9, fracture of the vault or base of skull; 803.0–804.9, other and unqualified multiple fractures of the skull; 850.0–854.1, intracranial injury, including concussion, contusion, laceration, and hemorrhage; 950.1–950.3, injury to optic nerve and pathways; and 959.01, head injury, unspecified. A total of 66,357 visits were found that included a TBI diagnosis.

Demographic descriptions of the population including age, gender, and race/ethnicity were made, along with the numbers of visits that had an Injury Severity Score (ISS) of <16 (nonsevere injury) and ≥16 (severe injury) and a description of the numbers of visits by length of stay in the hospital.

For the entire sample, estimates of the numbers of visits meeting physiologic guidelines of the ACS-COT/CDC Guidelines for Field Triage of Injured Patients were made. These guidelines include a GCS score <14, an SBP <90 mmHg, and a respiratory rate (RR) <10 or >29 breaths/min for patients 1 year of age or older or <20 breaths/min for patients less than 1 year of age. Of this population, the numbers of people with injury incidents who died either in the emergency department or in the hospital after admission were estimated. Patients who were dead on arrival were removed from analyses. Only visits that had complete information on both demographics and physiologic criteria, including death, were included in the analyses. After applying the exclusion criteria, a total sample size of 51,952 visits were made available for analyses. Analyses were conducted to test the randomness of missing data, and no bias was noted.

Bivariate analyses of mortality and meeting the guidelines were conducted using chi-square analyses to determine whether there was a significant difference in mortality between those meeting guidelines and those not meeting guidelines. Additional analyses included multiple logistic regression models using mortality as the dependent variable and estimated odds of dying for meeting guidelines while controlling for age, gender, race/ethnicity, injury severity, and length of stay. All analyses were conducted at an alpha level of 0.05 using SAS PROC SURVEY procedures (SAS Institute, Inc., Cary, NC) to take into account the complex sampling design of the survey.

Results

Approximately 70% of the visits within the study population consisted of male patients. Patients ranging in age from 18 to 45 years represented the largest proportion of visits (49.5%), and patients aged 46 to 64 years represented the next largest proportion of visits (21.4%). The vast majority of visits (65.5%) were made by patients identified as white. Nearly two-thirds (62.5%) of the patients had an ISS ≤15. The majority of the patients (55.4%) had a length of stay in the hospital of at least three days. An overwhelming majority of patients (79.9%) had a GCS score of 14–15. Approximately 13% of the patients had a severe TBI (GCS score 3–8). A very small percentage of patients (3.8%) had an SBP less than 90 mmHg. Similarly, a small percentage of patients (11.4%) had an RR less than 10 or greater than 29 breaths/min for adults or less than 20 breaths per minute for infants less than 1 year of age (Table 1).

Bivariate associations suggested a significant relationship between meeting the physiologic criteria and mortality. A greater proportion of patients meeting the GCS criteria of GCS score ≤13 died compared with those not meeting the GCS criteria (26.5% vs. 1.7%; $p \leq 0.05$). Visits in which patients had an SBP less than 90 mmHg at the time of arrival had a greater proportion of patients dying compared with visits in which patients did not meet this criterion (49.3% vs. 5.0%; $p \leq 0.05$). The RR guidelines also demonstrated this relationship:

Visits in which patients had an RR less than 10 or greater than 29 breaths/min among adults and less than 20 breaths/min for infants less than 1 year of age had a greater proportion who died compared with visits not meeting the RR criteria (31.8% vs. 3.5%; $p \leq 0.05$). These relationships appeared to be stronger when combining criteria. The proportion of visits with patients who died and who met GCS and SBP criteria was 70.9%. The proportion with patients who died and who met GCS and RR criteria was 41.4%. The proportion with patients who died and who met SBP and RR criteria was 73.4%. Visits in which all three criteria were met had an 81.2% proportion of patients who died. All the relationships were significantly different compared with visits that did not meet the guidelines, at $p \leq 0.05$ (Table 2).

Multivariate logistic regression models controlling for age, gender, race/ethnicity, ISS, and length of stay demonstrated significant relationships between dying and meeting the physiologic criteria. Visits in which patients met the GCS criteria had 17 times higher odds of death compared with those visits in which patients did not meet the GCS guidelines (odds ratio [OR] 17.4; 95% confidence interval [CI] 10.7–28.3). Those meeting the RR criteria had 20 times higher odds of death compared with those who did not meet the criteria (OR 20.3; 95% CI 13.4–30.8). Those meeting the SBP guidelines had nearly 19 times higher odds of death compared with those who did not meet the guidelines (OR 18.6; 95% CI 14.0–24.7). Finally, the patients who met all three of the physiologic criteria had nearly 70 times higher odds of death compared with patients who did not meet all three of the physiologic criteria (OR 67.8; 95% CI 48.3–95.3) (Table 3).

Discussion

These analyses underscore the importance of the ACS-COT/CDC Guidelines for Field Triage of Injured Patients by demonstrating that TBI patients triaged to level I and II trauma centers meeting the physiologic criteria of the guidelines have significantly greater odds of death. These data also demonstrate the contribution of each of the physiologic criteria in terms of acuity of the TBI patient and show that GCS score is the strongest predictor of death among patients who have sustained head injuries, even when a patient is transported to a trauma center. These data support the continued use of the field triage guidelines for optimizing transport decisions for patients with TBI.

Transport decisions made at the injury scene can affect TBI patient care and ultimate outcome. The field triage guidelines are used to determine whether a trauma patient requires the specialized critical injury care offered in trauma centers. Organized trauma systems that take information regarding possible brain injury, dispatch the appropriate level of care, and make informed decisions regarding destination are pivotal in delivering optimal care. The transport of TBI patients to higher-lever trauma centers is critical because prompt neurosurgical care is available at level I and II trauma centers.[24,25] For the management of severe TBI, advanced neurosurgical care typical of high-level trauma centers may be necessary to decrease internal brain pressure via use of an intracranial pressure **monitoring** or other advanced-care procedures recommended by the Brain Trauma Foundation.[26] Because TBI is often complicated by multiple injuries and approximately 30% of all injury-related deaths involve a TBI,[3] there is additional justification for TBI patients to be treated at a trauma center.

Limitations

This study has several limitations that should be considered. Our study is limited to the predefined variables contained in the NTDB as well as those limitations outlined by the ACS-COT on the use of the NTDB-NCS.[21] Similarly, there are limits inherent to the study's retrospective design. Another limitation is that multiple trauma was not a control variable; thus, physiologic criteria in the field triage guideline may be due to other injuries, in addition to TBI. However, an attempt was made to control for multiple traumas by including the ISS in the models so that more variance could be explained through this variable and the contribution of physiologic measures to the outcomes would be more clear. Outcome data were limited to the hospital stay only, and the authors cannot comment on the impact of the above factors on any longer-term outcome measures. It is also unknown whether the TBI patients were triaged to the trauma center because of application of the ACS-COT/CDC field guidelines or because of distance and convenience factors.

It is also important to consider that there may be differences in the treatment and outcomes of head injuries treated at different levels of trauma centers. This study examined only level I and level II trauma centers. The NTDB research data set collects data only on level I and level II trauma centers. Therefore, the utilization of the larger trauma registry would be useful, and examining outcomes among multiple levels of trauma centers would be an important future research endeavor.

In 2011, the National Expert Panel on Field Triage was reconvened to review the 2006 ACS-COT/CDC Guidelines in the context of recently published literature as well as the experience of states and local communities working to implement the Guidelines, and sought to make recommendations regarding any changes or modifications to the Guidelines. As a result of this process, modifications were made to the content of the Guidelines, focusing on the specific criteria, the language used in the transition boxes between the individual steps (physiologic, anatomic, mechanism of injury, and special considerations), and the layout of the Guidelines. The modifications reflect the results of the Panel's deliberations and include changes made upon the best available evidence, as well as incorporate the experiential base that the CDC has developed through its close work with states, national organizations, communities, and individual providers.

No significant changes were made to the physiologic criteria in 2011, and the results of this paper confirm the need for those patients with physiologic abnormalities to be transferred to the highest level of care within the defined trauma system as defined by the newly released guidelines.[27]

Conclusions

The findings of this study support the validity of the ACS-COT/CDC physiology guidelines. Decisions made for triage of patients within the field are critical to saving lives. Physiologic criteria are the first step in determining need for specialized care of specific injuries, and these analyses have demonstrated the importance of these physiologic criteria. Additional study evaluating the use of field triage guidelines and outcomes will help refine triage schemes and aid in the understanding of their use. In order to save lives, it is imperative to provide quick decisions based on scientific evidence when treating injured patients in the field.

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Table 1

Population Characteristics of Traumatic Brain Injury Patient Visits Triaged to Level I and II Trauma Centers in the United States, 2007

Characteristic	Unweighted Frequency	Weighted Frequency	Percent Estimate (95% CI)
Gender			
Male	36,606	144,934	70.5% (69.7%–71.3%)
Female	15,346	60,680	29.5% (28.7%–30.3%)
Age			
0–17 years	7,309	27,208	13.2% (12.0%–14.5%)
18–45 years	26,411	101,869	49.5% (47.8%–51.3%)
46–64 years	11,005	44,029	21.4% (20.7%–22.2%)
65+ years	7,227	32,508	15.8% (14.5%–17.1%)
Race/ethnicity			
White	32,013	134,749	65.5% (61.4%–69.7%)
African American	7,125	27,345	13.3% (11.0%–15.6%)
Hispanic	6,651	21,075	10.2% (7.8%–12.6%)
Other	6,163	22,445	10.9% (7.8%–14.0%)
Injury Severity Score			
<16	32,480	128,511	62.5% (59.7%–65.3%)
≥16	19,472	77,102	37.5% (34.7%–40.3%)
Length of stay			
1 day	13,998	54,428	26.5% (22.7%–30.2%)
2 days	9,181	37,374	18.2% (17.0%–19.3%)
3+ days	28,773	113,812	55.4% (52.1%–58.6%)
GCS score			
3–8	7,496	27,957	13.6% (12.4%–14.8%)
9–13	3,347	13,450	6.5% (6.0%–7.1%)
14–15	41,109	164,206	79.9% (78.4%–81.4%)
GCS triage score			
≤13	10,843	41,408	20.1% (18.6%–21.6%)
14–15	41,109	164,206	79.9% (78.4%–81.4%)
Systolic blood pressure			
<90 mmHg	2,014	7,788	3.8% (3.4%–4.2%)
≥90 mmHg	49,938	197,826	96.2% (95.8%–96.6%)
Respiratory rate			
<10 or >29* breaths/min	6,521	23,349	11.4% (10.1%–12.6%)
≥10 and ≤29 breaths/min	45,431	182,265	88.6% (87.4%–89.9%)

Source: 2007 National Trauma Data Bank National Sample Program (NTDB-NSP).

*Includes <20 for <1 year of age.

CI = confidence interval; GCS = Glasgow Coma Scale.

Table 2

Patient Deaths among Traumatic Brain Injury Patient Visits Triaged to Level I and II Trauma Centers Meeting and Not Meeting Physiologic Criteria

Criteria	Unweighted Deaths	Weighted Deaths	Percent Estimate (95% CI)
GCS triage score			
≤13	2,746	10,965	26.5% (24.7%–28.3%) *
14–15	536	2,760	1.7% (1.0%–2.3%)
Systolic blood pressure			
<90 mmHg	965	3,838	49.3% (46.3%–52.3%) *
≥90 mmHg	2,317	9,886	5.0% (4.2%–5.8%)
Respiratory rate			
<10 or >29 † breaths/min	1,889	7,416	31.8% (29.4%–34.1%) *
≥10 or ≤29 breaths/min	1,393	6,309	3.5% (2.7%–4.3%)
GCS and SBP combined			
Yes	915	3,658	70.9% (67.8%–73.9%) *
No	2,367	10,066	5.0% (4.3%–5.8%)
GCS and RR combined			
Yes	1,843	7,176	41.4% (38.1%–44.7%) *
No	1,439	6,548	3.5% (2.7%–4.3%)
All three criteria			
Yes	795	3,144	81.2% (78.5%–83.9%) *
No	2,487	10,581	5.2% (4.5%–6.0%)

Source: 2007 National Trauma Data Bank National Sample Program (NTDB-NSP).

* $p \leq 0.05$, tested with chi-square.

† Includes <20 breaths/min for infants <1 year of age.

CI = confidence interval; GCS = Glasgow Coma Scale; RR = respiratory rate; SBP = systolic blood pressure.

Table 3

Adjusted Logistic Regression Models for the Likelihood of Death by Physiologic Criteria*

Physiologic Criteria	**OR**	**95% CI**
Glasgow Coma Scale score	17.4	10.7–28.3
Reference†	1.00	1.00–1.00
Respiratory rate	20.3	13.4–30.8
Reference†	1.00	1.00–1.00
Systolic blood pressure	18.6	14.0–24.7
Reference†	1.00	1.00–1.00
All three criteria	67.8	48.3–95.3
Reference†	1.00	1.00–1.00

Source: 2007 National Trauma Data Bank National Sample Program (NTDB-NSP).

*Controlling for age, gender, race, Injury Severity Score, and length of stay.

†Not meeting physiologic guidelines.

CI = confidence interval; OR = odds ratio.